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学位論文内容の要旨

Dissertation Abstract

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学 位 論 文 題 名

Ultrastructural Evaluation of Dentine Regeneration after Direct Pulp Capping with Mineral Trioxide Aggregate and Calcium Hydroxide Using Focused Ion Beam Scanning Electron Microscopy and Stimulated Emission Depletion

(MTA セメントおよび水酸化カルシウムを用いた直接覆髄後に再生される象牙質の超微細構造評価 —集束イオンビーム走査型電子顕微鏡および刺激誘起放出抑制顕微鏡による観察—)

Keywords (5) Direct Pulp Capping, *in vivo* model, Focused Ion Beam Scanning Electron Microscopy, Mineral Trioxide Aggregate, Stimulated Emission Depletion

The aim of this study was to investigate the ultrastructure of the mineralized tissue after direct pulp capping treatment using focused ion beam scanning electron microscopy (FIB-SEM) and stimulated emission depletion (STED) microscopy.

Eighteen male Wistar rats (36 maxillary first molars) were used in this study. Nine rats (18 molars) were allocated for histological evaluation and immunofluorescence imaging (STED), six rats (12 molars) for FIB-SEM observation, and three rats (6 molars) served as untreated controls; control molars were used for both immunofluorescence imaging and FIB-SEM. For experimental allocation, two molars from each rat were randomly assigned to one of three groups: NEX MTA (NMTA), Dycal, or no-capping material (NC). After 4 weeks, teeth were collected for histological analysis, FIB-SEM observation and immunofluorescence imaging. Tubulin-b3 and nestin expression were examined by immunofluorescence staining and

imaged with STED microscopy. The Kruskal–Wallis test followed by Dunn’s multiple comparisons test was performed to assess significant differences.

All experimental groups exhibited complete mineralized tissue formation near the exposure site. The NMTA group showed a significantly more regular odontoblastic layer than the Dycal and NC groups ($p < 0.05$). FIB-SEM demonstrated that NMTA induced a well-organized and continuous tubular structure, whereas Dycal and NC produced irregular, discontinuous, and poorly organized mineralized barriers. STED imaging of the NMTA group revealed strong and organized co-localization of tubulin- $\beta 3$ and nestin resembling primary dentine, whereas the Dycal and NC groups showed weak, disorganized, or absent signals and lacked co-localized processes. NMTA showed superior regenerative potential compared with Dycal, consistently promoting well-organized dentine bridge formation, a continuous odontoblastic layer, and coordinated nerve-like extensions. These results suggest that NMTA more effectively supports structural and functional regeneration of the pulp-dentine complex after direct pulp capping.